Space Weather Technical Forecast

Issued on Tuesday, 14 June 2022 at 01:17 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of M-flares. Chance of Active fluence Days 3 and 4 (16-17 June). Chance of G1/Minor Storms mainly Day 2 (15 June).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate in the last 24 hours, with a long duration M3 flare that peaked around 13/0400 UTC, most likely originating from AR3032. There are now nine sunspot regions on the visible disc, the largest and most complex of which is AR3032 in the northeast. A large CME was observed in association with the M3 flare. While the bulk of the ejecta is expected to miss the Earth, the results suggest a possible glancing blow in the early hours of the 15th.

Solar Wind / Geomagnetic Activity: The solar wind speed, as observed by DSCOVR at L1, showed an ongoing coronal hole high speed stream. Wind speeds were mostly between 500-550 km/s, before declining slightly to 450 km/s at the end of the period. Density has been mostly average. Total Interplanetary magnetic field strength, Bt, has been moderate but on a slight declining trend. The north-south component, Bz, varied moderately between +10/-10 nT. The phi angle was positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled, with a G1/Minor Storm interval between 13/0300-0600 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (10 MeV) was at Background levels. Electron flux (greater than 2MeV) was also at background levels. Corresponding 24-hour integrated electron fluence has been well below the Active (1e8 integrated pfu) threshold on a slight rising trend, ending at 3e6 integrated pfu observed at 14/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be occasionally Moderate through this period, with C-class flares and a chance of M-class flares.

Solar Wind / Geomagnetic Activity: A large CME was observed leaving the sun in the early hours of the 13th, in association with a long duration M3 flare. Its analysis revealed that while the bulk of the ejecta is expected to miss behind Earth's orbit, there is chance of a glancing blow early on the 15th +/- 9 hours. Solar wind speeds are expected to remain at slightly elevated levels on Day 1, under the waning influence of a coronal hole. They should then become elevated or perhaps strong on Days 2 and 3 (15th and 16th) under the influence of the CME, followed by the high speed stream originating from CH91 and CH90. Solar winds slowly easing on Day 4. Geomagnetic activity is expected to be mainly Quiet on Day 1 but mostly Active with a chance of a G2/Moderate Storm on Day 2, Unsettled to Active of Day 3 and mostly Quiet on Day 4.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10 MeV) is expected to be at background levels during this period. High energy electron flux (greater than 2

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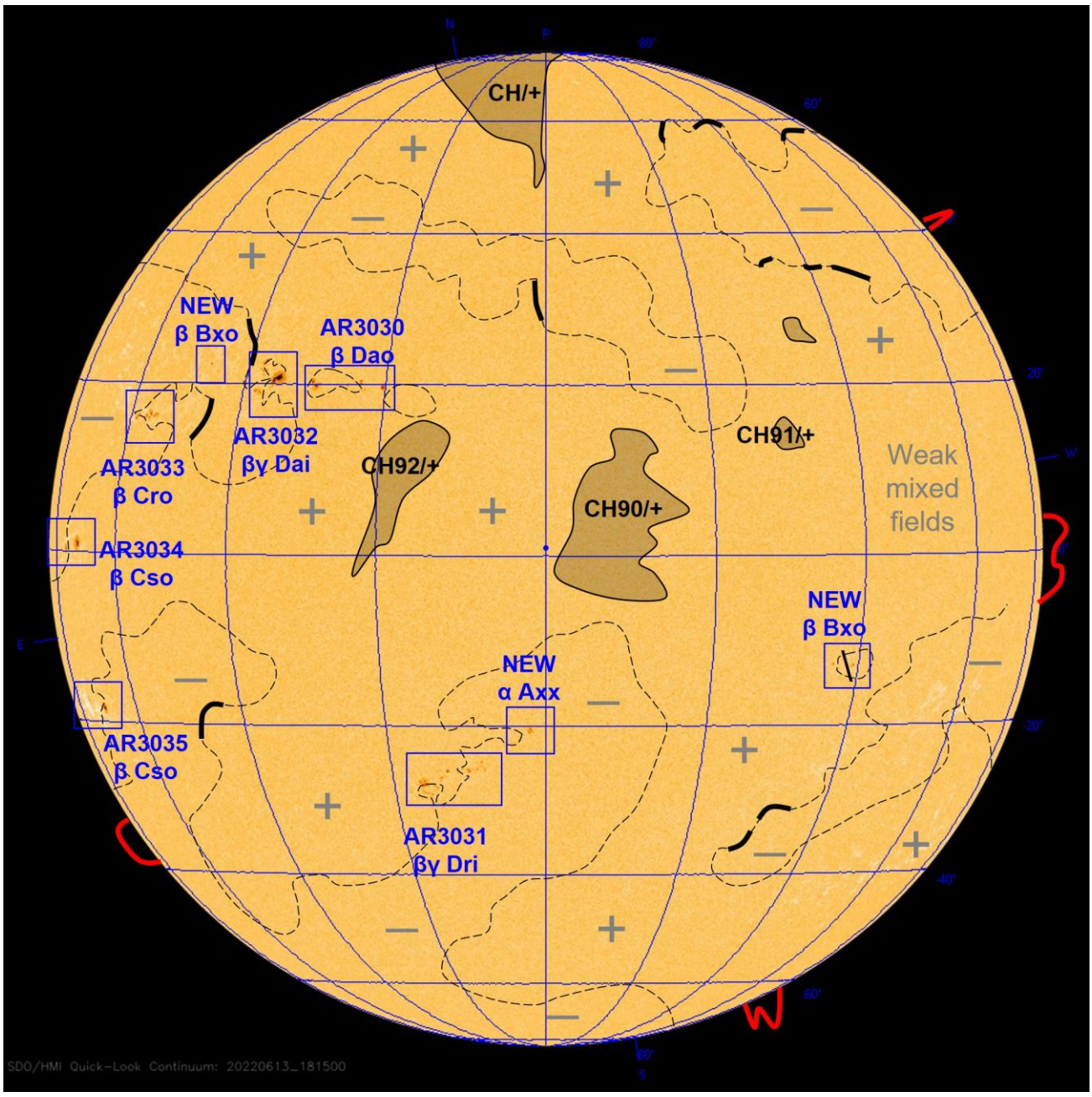
MeV) is expected to start at background levels but may increase to moderate or perhaps high levels during the period, due to high speed stream influences. Electron fluence is expected to follow a rising trend, with a chance of reaching Active (1e8 integrated pfu) levels later in the period.

Figure 1. Solar Analysis Valid 13/1800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Met Office Space Weather Technical Forecast

Geomagnetic Storms:

A large CME was observed leaving the sun in the early hours of the 13th, in association with a long duration M3 flare. Its analysis revealed that while the bulk of the ejecta is expected to miss behind Earth's orbit, there is chance of a glancing blow early on the 15th +/- 9 hours.

Solar wind speeds are now slowly decreasing, currently at slightly elevated levels, under the waning influence of a coronal hole. The source of this fast wind is still uncertain but may be due to CH89/+. This feature was facing the Earth a few days ago but was small and is no longer visible. The HSS from CH91/+ is expected to connect with Earth on Day 2 but will most likely be unnoticed given the expected arrival of the CME, with solar wind speeds of around 500-600 km/s. These elevated or perhaps strong values will most likely persist on Day 3, due to the influence of the HSS originating from CH90/+. This is a recurrent feature that generated solar wind speeds of around 500-600 km/s on the last rotation and so, similar values are expected this time round, most likely on Day 3 (16th). No CME or coronal hole fast winds expected on Day 4. Geomagnetic activity is expected to be mainly Quiet on Day 1 but mostly Active with a chance of a G1/Minor Storm or even G2/Moderate Storm on Day 2, Unsettled to Active of Day 3 and mostly Quiet on Day 4.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	5	30	10	1
Strong	G3	No	1	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
13/0645 UTC	Partial	AR3032	NE quadrant	1150 km/s	15/0600 UTC +/- 9hrs	Glancing blow likely

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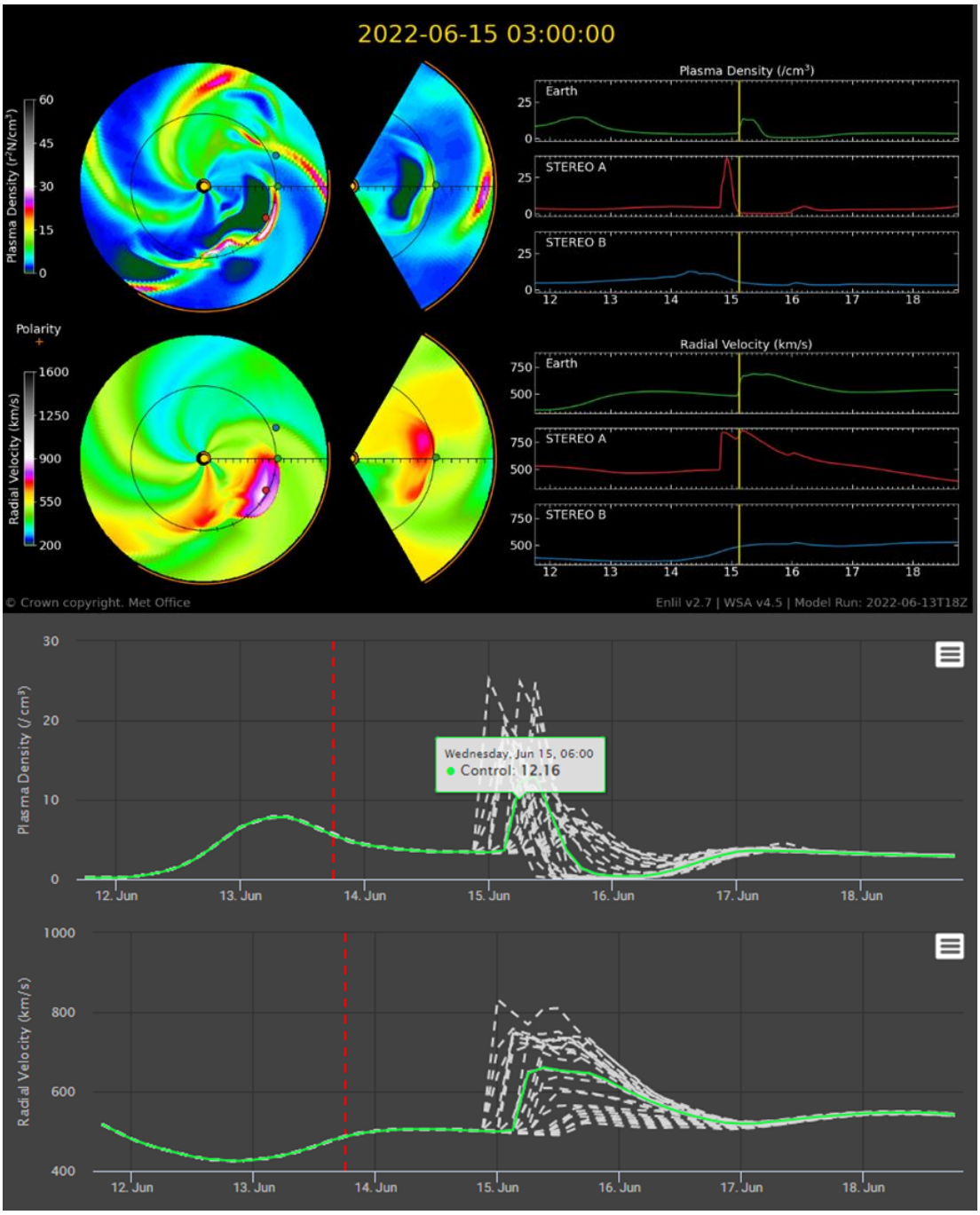
Figure 2: Enlil and ensemble suggesting a possible glancing blow from a CME early on the 15th.



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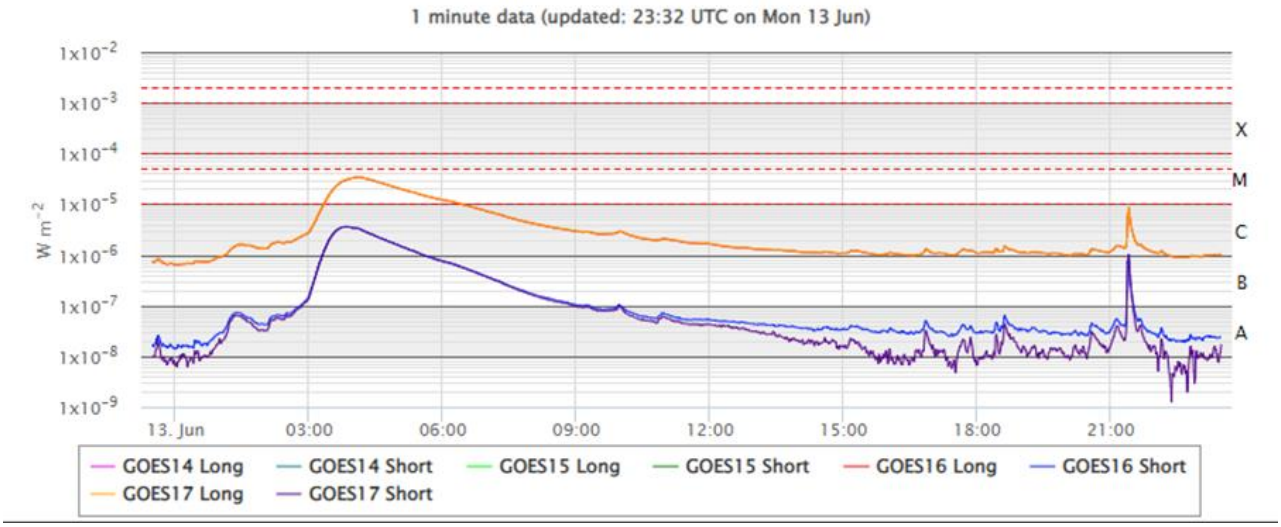
Radio Blackouts - X-Ray Flares:
Solar activity was Moderate in the last 24 hours, with a long duration M3 flare that peaked just after 13/0400 UTC, most likely originating from AR3032.

There are now nine sunspot regions on the visible disc. AR3032 is the largest and most complex region on the disc, although the delta spot has now disappeared and the region seems to weaken. AR3030 has seen a slight intensification of its leading spot, along with the development of two intermediate spots. AR3031 showed a rapid growth in the last few hours with the development of several spots, some of which are displaying a penumbra. AR3033 is becoming clearer as it rotates further onto the disc, with more spots becoming apparent. The two new regions near the east limb are both revealing trailing spots as they rotate further onto the disc. Three new regions have also recently emerged, all small and simple.

Solar activity is expected to be mainly Low, with a chance of further M-class flares, mainly from AR3031 or AR3032. X class flare probabilities are very slightly increased due to the presence of bright regions in the EUVI/AIA 195 imagery, suggesting that new sunspot regions may rotate onto the earth-facing disc in the coming days to supplement the elevated flare risk.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	30	35	40	40
Very Active	R3 to R5 X Class	No	5	5	10	10

Figure 3: Long duration M3 flare peaking at around 13/0400 UTC and originating from AR3032



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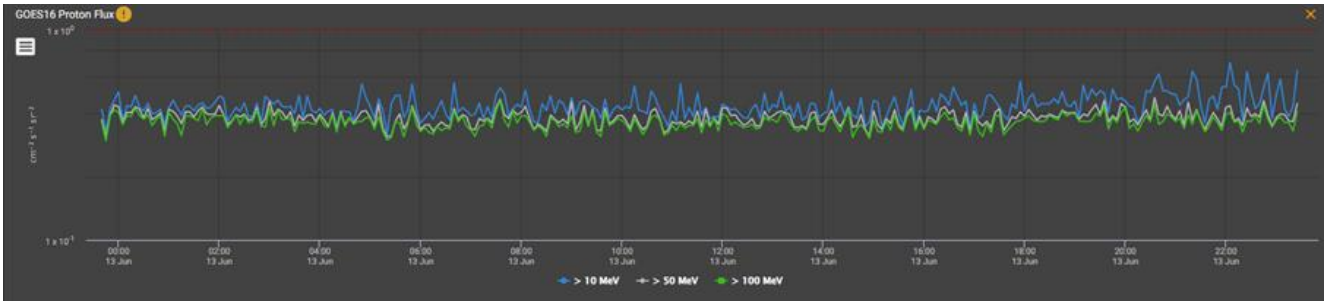
Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) was at background levels but displayed a slight rising trend at the end of the 24 hour period. It is expected to remain at this level through the period, albeit with a slight increase as the current spots transit westwards.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	2	2	2	2
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Latest proton flux, as seen by GOES 16, showing a slight rising trend



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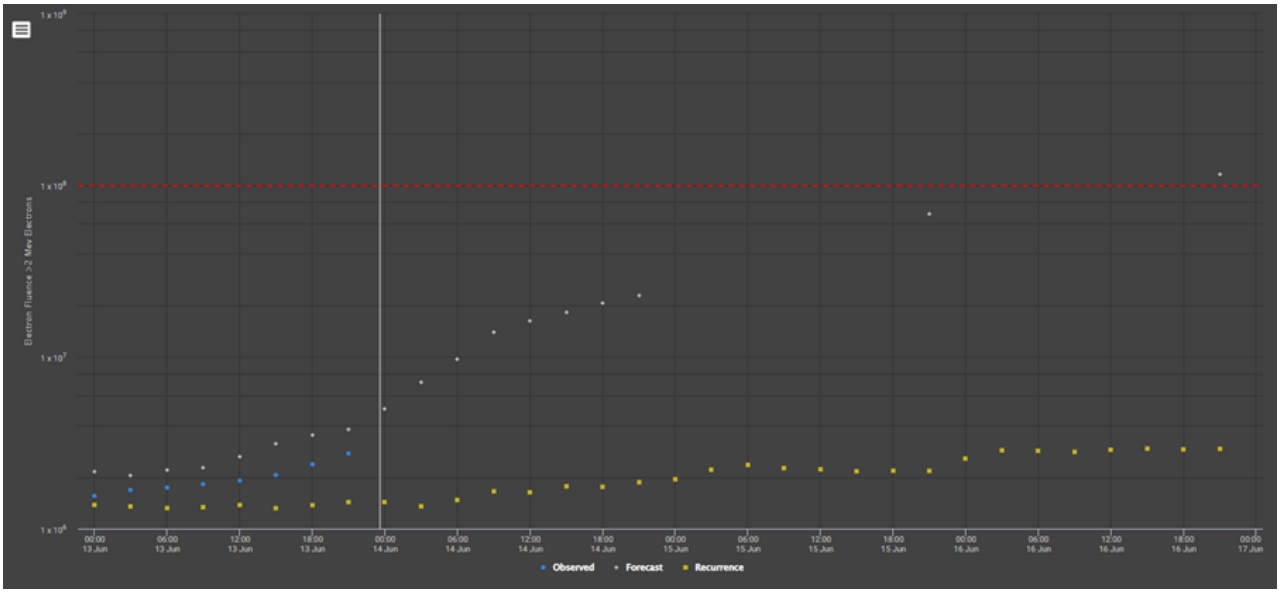
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) as observed by GOES-16 is currently at background levels. As the influence of the recent coronal hole high speed stream weakens, the Van Allen radiation belts may start to charge themselves. However, with the expected arrival of a CME in the early hours of the 15th (Day 2) and the subsequent distortion of the magnetic field, electron counts should temporarily drop, before recovering quickly on Days 3 and 4. Therefore an increasing trend is now considered more likely than not, particularly on Day 4 as the HSS originating from CH90 (and expected on Day 3) may suppress flux levels momentarily on Day 3. The level of confidence is however low as the forecast is essentially based on a glancing blow from the CME that was observed leaving the sun on the 13th. Overall, the chance of reaching Active levels is considered likely, particularly at the end of the forecast period. The REFM is unfortunately not going to be useful on this occasion, as unaware of the CME's risk, but suggests nonetheless a rise to just below Active levels by Day 2, which seems like a reasonable trend.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	10	10	30	40
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	10

Figure 5: Latest MOSWOC REFM forecast (white dots), observed 24-hour fluence values (blue dots) and persistence 24-hour fluence (yellow dots). Forecast suggesting a rise to near Active levels by the end of Day 2, considered to provide good guidance.



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